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BIOLOGICAL BULLETIN

TWO TRANSITIONAL STAGES IN THE DEVELOPMENT OF CYCLOPS SIGNATUS, VAR. CORONATUS.

A PRELIMINARY NOTE.

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While studying some of the inhabitants of a pool of spring water at Cold Spring Harbor, Long Island, during the months of July and August, I was perplexed by the constant occurrence of two comparatively large *Cyclops* that I was unable to identify as belonging to any known species.

The prevalent adult forms in the pool were *C. signatus* var. *tenuicornis* (*annulicornis*) and var. *coronatus* and *C. serrulatus*. That the forms in question bore no relation to *C. serrulatus* was quite evident. In certain characteristics they agreed with *C. signatus* but for some time I hesitated to associate them with *C. signatus* because of constant correlations in structure, and because the larger of the two forms was occasionally found to be sexually mature.

The smaller of the two cyclops, Plate VII., combined the following characteristics: the antennæ usually contained ten segments, but occasionally nine segments were present; the rami of the swimming feet were two-jointed, with an armature that indicated immaturity as follows:

First Foot.		Second Foot.	
Outer Ramus.	Inner Ramus	Outer Ramus.	Inner Ramus.
3 outer spines,	1 outer seta,	3 outer spines,	1 outer seta.
1 apical spine,	1 apical spine,	1 apical spine,	1 apical spine.
1 apical seta,	1 apical seta,	1 apical seta,	1 apical seta.
3 inner setæ,	5 inner setæ,	4 inner setæ,	5 inner setæ.

Third Foot.		Fourth Foot.	
Outer Ramus.	Inner Ramus.	Outer Ramus.	Inner Ramus.
3 outer spines,	1 outer seta,	3 outer spines,	1 outer seta.
1 apical spine,	1 apical spine,	1 apical spine	1 apical spine.
1 apical seta,	1 apical seta,	1 apical seta,	1 apical seta.
4 inner setæ,	4 inner setæ,	4 inner setæ,	3 inner setæ.

The rudimentary fifth foot was two-jointed, having an almost square basal segment bearing an immature seta on its outer distal angle, and a slightly elongated distal segment bearing three hairs.

The larger cyclops, Plate VIII., combined the following characteristics: the antennæ contained eleven segments; the rami of the swimming feet were three-jointed with an adult armature, as follows:

First Foot.		Second Foot.	
Outer Ramus.	Inner Ramus.	Outer Ramus.	Inner Ramus.
3 outer spines,	1 outer seta,	3 outer spines,	1 outer seta.
1 apical spine,	1 apical spine,	1 apical spine,	1 apical spine.
1 apical seta,	1 apical seta,	1 apical seta,	1 apical seta.
3 inner setæ,	3 inner setæ,	4 inner setæ,	3 inner setæ.

Third Foot.		Fourth Foot.	
Outer Ramus.	Inner Ramus.	Outer Ramus.	Inner Ramus.
3 outer spines,	1 outer seta,	2 outer spines,	1 outer seta.
1 apical spine,	1 apical spine,	1 apical spine,	1 apical spine.
1 apical seta,	1 apical seta,	1 apical seta,	1 apical seta?
4 inner setæ,	3 inner setæ,	4 inner setæ,	2 inner setæ.

The rudimentary fifth foot was two-jointed with an almost square basal segment, bearing an immature seta externally, and a distal segment, longer than broad, armed with two immature spines and a median seta.

The study of a large number of these forms showed that both forms were always found together; that they always accompanied *C. signatus*, var. *coronatus*, having seventeen antennal segments; that in the absence of strong color markings and hairs they gave evidence of being young; and that they were, as a rule, sexually immature, although the larger cyclops occasionally contained ova. I became convinced of their larval character, as well as of their relationship to *C. signatus*, and determined to test the correctness of the conclusion by breeding experiments. Accordingly, a few fertile females with appended embryos, were isolated in a carefully prepared aquarium. At the end of two months this aquarium was examined for the desired forms, when nu-

merous individuals in both stages were found to be present. Later, one cyclops with eleven antennal segments was found with numerous large ova in the ovaries.

The rearing of the young from the adults proves conclusively that the forms in question are transitional stages in the life history of a form with seventeen segments in the antennæ. The experiments show also that *C. signatus* may become sexually mature in the larval state.

That this sexually mature young was a true larva, and not a form in which the growth of only the antennæ had been retarded, is indicated by the relatively small size of the individual when compared with the adults, by the incomplete number of segments seen in the antennæ, and by the transparency of the skin and the general absence of hairs and spines.

In the formation of the antennal segments there is a constant sequence. The nine-jointed antenna becomes transformed into the ten-jointed antenna by the division of the third segment from the base into two small ones, and the eleven-jointed condition arises from the ten-jointed, by the formation of a short second segment, the permanent second segment of the seventeen-jointed antenna. Occasionally the antennæ contain twelve segments, but intermediate conditions between the eleven and the seventeen-jointed stages are not frequent. In *Signatus*, prior to the completion of segmentation in the antennæ, two greatly elongated segments (the seventh and eighth in the eleven-jointed stage) break up simultaneously into the required number of small segments, four and three respectively, while the third segment breaks into two, thus providing seventeen segments, the number in the adult.

In a former paper, "Heterogeny and Variation in Some of the Copepoda of Long Island," I was of opinion that "some facts point to the probability that the Cold Spring Harbor forms . . . are morphologically undeveloped." I am now convinced that those cyclops combining nine, ten and eleven joints in the antennæ, with a two-jointed fifth foot, having a distal segment armed with three undeveloped hairs, are transitional stages in the life history of *C. signatus*, although the variety is less easily determined.

The study of various larval stages of *C. signatus* shows the rudi-

mentary fifth foot to be the most characteristic organ by which the species can be easily identified even in very early stages. Whether the hairs on the fifth foot are setose or spiny depends in large measure on the age of the individual, and is of little importance.

There are two generally recognized varieties of the species *C. signatus*, namely, var. *coronatus* (*C. fuscus* of Jurine) and var. *tenuicornis* or *annulicornis*, called *C. albidus* by Professor Marsh.

Both of these forms occur side by side and are regarded by some authors, Herrick and Brady, as transitional stages of one and the same form, while other authors regard them as distinct varieties.

I do not wish at this time to express an opinion on the relationship of *C. coronatus* and *C. tenuicornis*, but the correlations indicated in this paper for *C. signatus*, var. *coronatus*, can also be observed in the forms described as *C. signatus*, var. *tenuicornis*, in which the hairs on the inner margins of the stylets are lacking, as well as the serrations in the hyaline plate in the sixteenth and seventeenth antennal segments; and in which the second segment of the antennule, as well as the basal segment of the rudimentary fifth foot, are relatively long, while in *coronatus* they are conspicuously short.

The armature of the fourth pair of swimming feet, often shown in keys to the *Cyclops*, is by itself of little value as a means of identification, since several distinct species agree in the armature of this appendage, although they have no agreement in any of the other swimming feet, nor in the larger outlines of the body. It is to be regretted that fuller details of the *Cyclops* are not given as a means of securing a rapid acquaintance with common forms, and with their later transitional stages, which occur in great abundance side by side with the adults, and, like the adults, are sometimes found with eggs.

COLD SPRING HARBOR,

LONG ISLAND, N. Y., July, 1905.

PLATE VII.

C. signatus, coronatus.

Leitz camera drawings. Reduced one half.

FIG. 1. An outline showing the proportions of the thorax, abdomen, and antennæ when there are but ten segments in the antennæ. 3×3 .

The abdomen has but three undifferentiated segments, to the last of which are attached the characteristic caudal stylets.

The antennæ reach to the posterior edge of the second thoracic segment, and contain ten segments each. Only the right antennule is represented.

FIG. 2. The external ramus of the fourth swimming feet. All the rami of the swimming feet are two-jointed. The proximal seta of the inner margin is conspicuously separated from the remaining setæ, which become the inner armature of the terminal segment after the formation of the third joint. 3×7 .

FIG. 3. The rudimentary fifth foot is characteristic of the species *C. signatus*. The hairs are neither setose nor spiny. 3×7 .

The internal fringe of hairs on the caudal stylets, the short, broad, basal segment of the fifth foot, and the short second joint of the antennule indicate that this is the larval form of *C. signatus coronatus*.

FIG. 4. An antenna with nine segments.

FIG. 5. An antenna showing the third segment dividing to form the tenth segment.

FIG. 6. An antenna with ten segments fully formed.

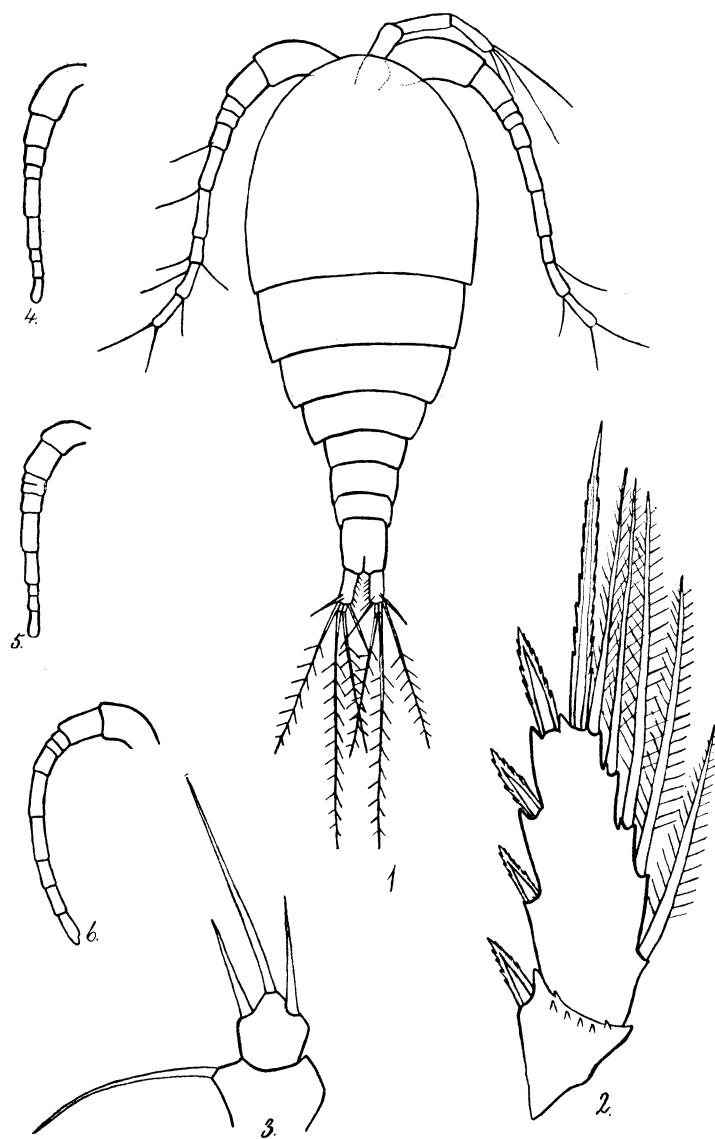


PLATE VIII.

C. signatus, coronatus.

Leitz camera drawings. Reduced one half.

FIG. 1. An outline showing the proportions of the thorax, abdomen and antennæ when the antennæ contain eleven segments. 3×3 .

The abdomen has acquired four segments in which there is still little differentiation. The caudal stylets remain unchanged.

The antennæ have acquired a new segment, the small second segment from the base of the antenna, making eleven in all. Only the right antenna is represented.

FIG. 2. The external ramus of the fourth swimming feet. All the rami of the swimming feet are three-jointed, and in their armature, have reached the condition of the adult. 3×7 .

FIG. 3. The rudimentary fifth foot remains practically unchanged. 3×7 .

